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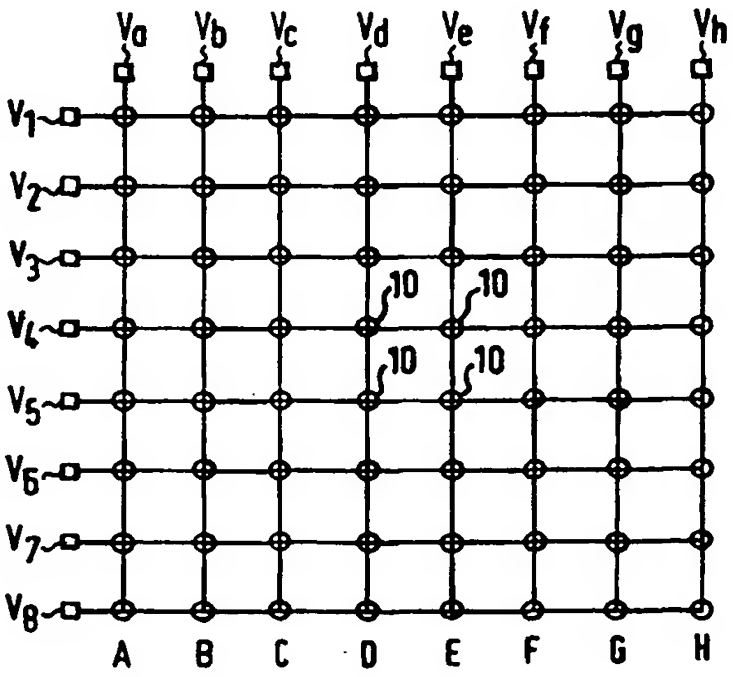
(57) Abstract

A support assembly for selective support of an article (2) from a face thereof, comprising an array of pneumatically actuated cylinders (6) movable from a retracted to a support position, wherein the cylinders (6) are arranged in an array and their actuation is controlled by a valve mechanism comprising a number of control valves (V_a–V_h, V_1–V_8) which is less than the number of cylinders, such that each cylinder is controlled by actuation of two valves (V_g, V_6) which determine uniquely which cylinder is actuated. A cylinder assembly having a locking mechanism for use in the array is also disclosed.



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PNEUMATIC APPARATUS USING AN ARRAY OF PNEUMATIC CYLINDERS

This invention relates to pneumatic apparatus. In particular, but not exclusively, it relates to a pneumatic cylinder and to an apparatus, using an array of pneumatic cylinders.

The apparatus may be an apparatus using an array of pneumatic cylinders to support bodies such as circuit boards. Alternatively the apparatus may comprise an array of pneumatic cylinders which are selectively energised for diagnostic, testing, sampling or other purposes, such as for the sampling/testing of blood or other biological samples. Many other types of pneumatic apparatus using an array of cylinders may fall within the scope of the invention.

In the manufacture of electronic circuit boards, there is often a requirement to support the board after components have been put on the board, whilst soldering, screen printing, or other processes are done on the reverse side of the board from the side on which the components are mounted. It is desirable that the board be as well supported as possible during these processes, but of course the points of the board which are supported should not be ones which have a component on; they should only be those parts of the board in between components.

If any one particular circuit board having one particular circuit and

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component configuration is to be treated, then a jig may be custom-made. More commonly, however, a support mechanism is intended to hold a number of different circuit boards with different component configurations and thus must have some way of altering the positions of the various supports. Figure 1 schematically shows a support mechanism which has a number of pins 1 which can be raised or lowered, typically pneumatically. A circuit board 2 is placed above the pins and the circuit board has a number of components 3 mounted on the underside of it. Only those pins such as pins 4 and 5 are raised, which do not impinge upon a circuit component. Any pins which lie directly underneath the circuit component are not raised so that they do not strike or impart any pressure upon a component.

Up to now, each pin has been actuated by its own individual valve mechanism. Since an array may typically have about 1800 pins, this has required that number of valve mechanisms, one for each pin. This can result in a structure which is mechanically complex, difficult to maintain and expensive.

The present invention arose in an attempt to provide an improved support assembly and pneumatic cylinder.

According to the present invention there is provided a pneumatic assembly, comprising an array of pneumatically actuated cylinders moveable from a retracted to a support position, wherein the cylinders are arranged in an array

and are actuated by a valve mechanism comprising one valve for each row of cylinders and one valve for each column, whereby actuation of a particular cylinder is controlled by actuation of the respective row and column valves for that cylinder.

The assembly may be used as a support assembly for selective support of an article from a face thereof.

The invention accordingly significantly reduces the number of valves required to control an array. For example, in an array of 44 x 44 cylinders, only 44 + 44 = 88 control valves are required, compared to 1936 valves with prior art systems. Furthermore, since the actuating valves are situated remotely from the actual cylinders, and are perfectly connected thereto by passages in a support structure for the cylinders, embodiments of the invention are far simpler, easier to maintain and cheaper than prior art arrangements. It also becomes possible, upon failure of a single cylinder, to simply remove and replace that cylinder.

According to the present invention there is further provided a support assembly for selective support of an article from a face thereof, comprising an array of pneumatically actuated cylinders having pistons movable from a retracted to a support position, wherein actuation of the cylinders is controlled by a valve mechanism comprising a number of control valves which is less than the number

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of cylinders, such that each cylinder is controlled by actuation of two valves which determine uniquely that cylinder.

According to the present invention there is still further provided a pneumatic cylinder, comprising a piston slidable relative to a cylinder body, means for enabling input of a pneumatic supply to cause relative movement of the pin and the body, and a locking means preventing relative movement until unlocked.

According to the present invention there is further provided a pneumatic cylinder, or a support assembly, including any one or more of the novel features herein described.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows schematically a circuit board held on a support arrangement;

Figure 2 shows schematically an array of pneumatic cylinders and controlling valves;

Figure 3a shows a pneumatic cylinder;

Figure 3b shows an enlarged view of one end of the pneumatic cylinder;

Figure 3c shows an enlarged view of the other end of the cylinder;

Figure 4 shows the equivalent pneumatic diagram of the cylinder;

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Figure 5 shows a pneumatic diagram of an alternative cylinder; and

Figure 6 shows an enlarged view of one end of a cylinder embodying Figure 5.

A support mechanism according to the present invention is generally of the construction shown in Figure 1, having a plurality of pneumatically actuated pins 1 each extendable from a pneumatic cylinder 6 which is mounted between upper and lower support plates 7, 8 respectively. These support plates have channels formed within them for allowing the passage of air or gas for the pneumatic system to be passed around and into the cylinders. The cylinders themselves are supported within laterally spaced bores in the upper and lower mounting plates 7 and 8 with their respective gas inlet and outlet ports adjacent to respective channels for the passage of compressed air or gas for the pneumatic system.

As shown more clearly in Figure 2, the pneumatic cylinders 6 are arranged in a regular array which may, in a typical embodiment, be a 44 x 44 array, although the figure for clarity only shows an 8 x 8 array. The array may be of any size within the scope of the invention or course. In embodiments of the present invention, instead of each cylinder being provided with its own control valve mechanism, only a limited number of control valves are required. As shown in the figure, there are two sets of valves, valve V_a to V_h and valves V_1 to V_8, respectively. Each of the valves V_a to V_h provide a pneumatic supply to all the cylinders in one of the columns A- H. Similarly, each of the valves V_1 to V_8

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provides, when operated, a pneumatic supply to one of the respective rows of cylinders. It should be noted that valves V_a to V_h and V_1 to V_8 are control valves. Further valves are required to provide power for the actual upwards/downwards displacement of the pins of the cylinders. The control valves are used in effect as switches to determine which cylinder is to be actuated.

The cylinders are arranged such that any one cylinder is only actuated, i.e. raises its pin, when both its column and row valves are actuated. Hence, any cylinder can be selectively actuated by actuating one row valve and one column valve. In the figure, for example, the cylinder shown at 9 is actuated at one time by actuating valves V_g and V_6.

The cylinders are arranged such that once actuated, i.e. once the pin is raised, it stays raised until operated by a purging supply which retracts the pin. In use, then, a controller, such as a computer or NC controller (not shown) outputs, serially, data respective of a plurality of pairs of valves, in order to build up a number of cylinders which have raised pins. So, if the four pins labelled 10 in the figure are to be raised, the controller first outputs codes instructing V_d and V_4 to actuate, then V_e and V_4, then V_d and V_5 and finally V_e and V_5. This will result in all four pins 10 being in the raised position. The pins raised in any complete pass need not of course all be adjacent to each other and can be distributed at will amongst the array. Any number of pins, from one (or indeed none) up to all the pins, can be actuated in a single pass.

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Figure 3a illustrates one of the pneumatic cylinders according to one embodiment of the invention. The cylinder comprises a piston rod (pin) 11 mounted generally within a barrel 27 for relative movement therebetween. The pin is provided, at its lower end, with a ball retaining portion 12 which has a lowermost portion bearing two locking ball bearings 13. These are mounted in radial holes in a reduced diameter end portion and are held in place by retaining clips 14. The balls are of a diameter slightly greater than the depth of the retaining holes such that, when forced outwards they impinge into respective notches 15 on an inner surface of cylinder block 16. When pressed into notches 15, the balls 13 prevent movement of ball retainer 12 and its rigidly attached piston rod 11 relative to the barrel 27. The balls have to be released from their notches before the piston rod can move and therefore they act as a locking mechanism. Other locking mechanisms may be used in accordance with the invention and there could be more or less than two of these.

Lower cylinder block 16 is also provided with a stop 28, a valve stem 17 which can be displaced longitudinally to push balls 13 into notches 15 and three sets of openings 18, 19 and 20 which act as input ports from the pneumatic control system of the apparatus. Each set of input ports such as set 18 comprises, in one embodiment, a plurality of holes of approximately 1mm in diameter bored approximately 90° apart around the circumference of the cylinder block. A plurality of O-rings 21 on the periphery of the cylinder block serve to seal the

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areas between the respective input ports. Internal O-rings 22 are also provided as is an internal clip 23.

At the other end of the cylinder, there is provided an upper cylinder block 24 which is fitted onto the end of barrel 27 and through which pin 11 protrudes such that pin 11 can be relatively slidable longitudinally relative to barrel 27. Several O-rings are provided for sealing the spaces between upper cylinder block 24 and the barrel, and between the block and the upper mounting plate 7 (Figure 1). Further inlet ports 26 are provided, spaced around the periphery of upper block 24 for a purging supply to return a piston to its unactuated position.

The operation of the cylinder is best described with reference to Figure 4 which shows an equivalent pneumatic diagram thereof.

The diagram shows two valves, valve A and valve B which are representative of individual ones of each of the respective sets of valves V_1 to V_8, and V_a to V_h. Two further valves are provided in the system. These are valve C and valve D. These two valves are linked to all of the cylinders in the assembly of Figure 2 by a series of channels or bores in plates 7 and 8. Three vertically displaced sets of orthogonal bores are provided in lower plate 8, and a set of bores in one vertical plane are provided in upper plate 7. The bores in plate 8 connect valves to inlets 18, 19 and 20, and the bores in plate 7 provide gas to inlet 26. Valve C provides a source of compressed air, when desired, to inlet 20 of Figure

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3b. Valve D provides a source to inlet 26 at the top of each cylinder (Figure 3c). Valves C and D may be combined into a single valve which supplies no air, or supplies inlet 20 or inlet 26 selectively.

Valve A, which can selectively receive a 5 bar supply is connected to inlet 19. Valve B, which can selectively receive either 5 bar or 2.5 bar, is connected to inlet 18. As shown, inlet 18 is below and inlet 19 is above a displaceable body 30 which is connected to valve stem 17 so as to move with stem 17. The upper part of valve stem 17 serves, as shown in Figure 3b, when displaced upwards, to displace balls 13, mounted in radial holes in piston/ball retainer 12, radially outwardly into notches 15 in cylinder block 16. In Figure 4, this is simply shown as a locking mechanism 31. When the locking mechanism is actuated, it prevents upward movement of piston rod 11, even when a pressure from valve C is applied underneath the rod, which would normally cause the rod to move upwards. The locking mechanism can only be released when valve stem 17 is lowered, by lowering body 30. This is achieved by differential pressures between valve A and valve B. In effect, they act as an AND gate such that when the pressure is applied through valve A and valve B are equal, the stem does not move. If a pressure of 5 bar is applied to valve A, and valve B only applies a pressure of 2.5 bar, then the valve stem will be depressed downwards, serving to release balls 13. If a pressure is present via valve C at this point, then the piston rod 11 will be freed and will be forced upwards, into the actuated position.

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In operation, valve C is continually energised, providing air to inlet 20.

Thus, selective actuation of valves A and B causes one particular pin corresponding to the particular combination of which of valves A and valves B is chosen, to be actuated. That is, its locking mechanism is unlocked and the pin is displaced upward.

Valve B preferably does not revert to zero pressure, but instead applies a non-zero pressure when not actuated, such as 2.5 bar, or indeed some other non-zero pressure, so that a residual pressure is applied to the base. This is to overcome residual pressures and wedging forces in the system and also because, as air is continually applied through inlet 20, there is always a down force on stem 17. If valve B reverted to zero, this down force would push down 17 and unlock the locking mechanism, when this is not required. All the pressures shown can of course be varied as desired. Instead of the pressure of 2.5 bar, or some other pressure lower than 5 bar applied to valve B, a simple spring may be used.

The valves are actuated by electronic signals from a control unit as described, in turn, in order that all the desired pins in the array will be actuated in turn for a particular application.

Referring to Figures 2 and 4, valve A of Figure 4 is one of the valves V_a to V_h to Figure 2, and valve B is one of the valves V_1 to V_8. If cylinder 9 of Figure 2 is required to be operated, then valve B is set initially at 5 bar and valve A is off.

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Air is continually supplied through valve C. Valve B (V_h) is then lowered to 2.5 bar. This has no effect on any of the cylinders in column H as all of valves V_1 to V_8 are off, forcing up all the locking mechanisms. Valve V_6 is then increased to 5 bar and this forces the locking mechanism of pin 9 (V_g,V_7) down, unlocking it. The pressure applied at 20 then sends up pin 11. The remaining pins in the row determined by valve V_6 remain down as they still have 5 bar pressure applied from the respective column valve V_a to V_f and V_h.

Alternatively, more than one cylinder can be actuated simultaneously. Referring again to Figure 2, to actuate pins 10, initially all of valves V_a to V_h ('valve B') are at 5 bar, and all of valves V_1 to V_8 are at 0 bar. V_d and V_e are then lowered to 2.5 bar. V_4 is then raised to 5 bar. This causes the relevant cylinders in the row acted upon by V_4, V_d and V_e to raise. V_5 is then raised to 5 bar (V_4 may now be lowered to zero – the pins are already up in the row and are therefore unaffected) and the relevant pins acted upon by V_5, V_d and V_e are raised. Similarly, any combination of cylinders, or cylinders within particular rows or columns, may be actuated as desired.

After all the desired pins have been raised, a circuit board may be mounted upon the apparatus and worked upon. Alternatively of course many other types of substrate or body may be mounted upon a support mechanism within the scope of the present invention. Once the body to be supported has been worked on and has

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been removed, then the system may be purged through valve D which forces all of the pins downwards to their rest position.

In one example of an initiation process for the system, all the stems 17 are lowered. As a result, all the pins 11 rise. This avoids any jamming when the pins are eventually lowered for operation. The pins are all lowered by applying pressure via valve D, through orifices 26 (Figure 3c). Finally, all the locking stems 17 are raised, engaging all the locks. Selective unlocking and pin actuation can then begin.

Although the preferred embodiment of a locking mechanism is of balls which are forced into notches or other detents within the body of the cylinder, many other locking mechanisms will be apparent, which are unlocked by a pneumatic mechanism.

The valves may be solenoid valves, or may be other types of pneumatic valve.

A significant advantage of the present invention is that, in the event of a failure or malfunction of a cylinder, that cylinder can be simply removed and replaced by literally pulling or pushing it from its support plates and inserting a replacement. No separate valves need connecting. The cylinders are simply aligned with the various channels or bores in the support plates.

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The term pneumatic cylinder used herein refers generally, as known in the art, to a pneumatically operated assembly having a piston rod or pin movable relative to an outer body.

As described, instead of being used as a support, a pneumatic assembly may be used as a diagnostic, testing or sampling array, e.g. for sampling from a selected one of an array of test tubes, vials, etc, filled with blood or other samples. This may mean that the cylinders/pistons/pins are extended downwardly, but in effect the same or similar actuation and locking mechanisms are required.

Figure 5 shows an alternative cylinder design, in which only two pressure inputs 18a, 19a are required below the locking mechanism. This embodiment is therefore simpler than the embodiment of Figure 4.

Pressure 'E' from valve E (5 Bar) can be applied above body 30 at 19a. Pressure F from valve F (1.75 or 6 Bar) can be applied below body 30 at 18a. A plurality of valves E, equal to the number of columns for example, and a plurality of valves F, equal to the number of rows, for example, are provided. All of valves F are supplied by a single valve G as shown which acts as a source for both the 6 and 1.75 Bar (via a restrictor) pressures. The top of the cylinder is provided with pressure H from a single valve H (5 Bar). Only 1 valve H is required in the system.

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The sequence of use is as follows:

To programme, firstly a row is selected and pressure 'F' is reduced to 1.75 Bar. A column is selected and column pressure 'E' is then applied at 5 Bar to unlock and extend the cylinder. Pressure F is then restored to 6 Bar and Pressure E is exhausted. This is repeated for all desired rows and columns. Pressure E is then applied to all columns to fully extend selected cylinders. The programming is then complete.

To reset, pressure F is exhausted to zero (by de-energising valve G). All valves E are then energised to apply pressure E (5 Bar) to release the locks. All ports E are then exhausted (de-energise valves E). Valve H is then energised to apply pressure to the end ports of all the cylinders to retract the cylinders. Valve F is then energised to apply pressure F (6 Bar) to lock the cylinders in the retracted position. Pressure H is then exhausted and the reset is complete.

Before each programming cycle, the start conditions are therefore:

Valve E	De-energised
Valve F	De-energised
Valve G	Energised ("Locks-On")
Valve H	De-energised

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Figure 6 shows in detail one embodiment of a cylinder in accordance with Figure 5. This includes a threaded joint 100 to ensure alignment. Many variations may be used having the same general structure and functioning. Note that the pressure valves given are by way of example only and may vary with different system or uses.

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CLAIMS

1. A pneumatic cylinder, comprising a piston slidable relative to a cylinder body, means for enabling input of a pneumatic supply to cause relative movement of the pin and the body, and a mechanical locking means preventing relative movement until unlocked.

2. A pneumatic cylinder as claimed in Claim 1, wherein the locking means comprises one or more locking elements and a radial-force-applying member for applying radial force to the locking elements to cause them to engage detents to prevent relative movement of the pin and cylinder.

3. A pneumatic cylinder as claimed in any of Claims 1 or 2, wherein inlets are provided for two control inputs which act on opposing sides of the radial force-applying means, or a body connected thereto, in order that a specified combination of pressure inputs causes locking or unlocking.

4. A pneumatic cylinder as claimed in any of Claims 1 to 3, wherein an input is provided which, when the locking mechanism is unlocked, enables the piston to be moved.

5. A pneumatic cylinder as claimed in any of Claims 1 to 3, wherein unlocking of the locking mechanism also causes relative movement of the pin.

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6. A pneumatic cylinder as claimed in any of Claims 1 to 5, wherein an input is provided which enables the piston to be retracted into or towards the cylinder.

7. A pneumatic assembly comprising an array of pneumatically actuated cylinders having pistons movable from a retracted to an extended position, wherein actuation of the cylinders is controlled by a valve mechanism comprising a number of control valves which is less than the number of cylinders, such that each cylinder is controlled by actuation of two valves which determine uniquely that cylinder, and wherein each piston, after selection, remains extended, so that a plurality of pistons can be extended as desired; and comprising means for causing all the extended pistons to retract when desired.

8. A pneumatic assembly comprising an array of pneumatically actuated cylinders having pistons moveable from a retracted to an extended position, wherein the cylinders are actuated by a valve mechanism comprising one valve for each row of cylinders and one valve for each column, whereby actuation of a particular cylinder is controlled by actuation of the respective row and column valves for that cylinder, and wherein each piston, after selection, remains extended, so that a plurality of pistons can be extended as desired; and comprising means for causing all the extended pistons to retract when desired.

9. A pneumatic assembly as claimed in Claim 7 or Claim 8, wherein the actuation of valves is controlled by a control unit.

10. A pneumatic assembly as claimed in Claim 9, wherein the cylinders are arranged that, once actuated, they remain in the actuated position until deactuated, wherein the control unit outputs a plurality of data representative of pairs of valves in order to serially raise a plurality of cylinders to their extended position such that, after all the data has been output, a plurality of cylinders at desired positions are in the extended support position.

11. A pneumatic assembly as claimed in Claim 10, wherein each cylinder comprises a mechanical locking mechanism and selective actuation of the relevant pair of valves for that cylinder cause the locking mechanism to unlock to enable movement of the cylinder.

12. A pneumatic assembly as claimed in Claim 11, wherein the locking mechanism comprises one or more locking elements and a means for exerting a radial force against the elements to cause them to engage detents in the body of the cylinder.

13. A pneumatic assembly as claimed in Claim 11, wherein actuation of the relevant pair of valves for a cylinder frees the locking elements and causes the cylinder to take up an actuated position.

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14. A pneumatic assembly as claimed in Claims 12 or 13, wherein actuation of the relevant pair of valves for a cylinder causes downwards movement of the radial-force-exerting body so as to free the locking elements.

15. A pneumatic assembly as claimed in any of Claims 7 to 14, wherein the cylinders are located in upper and lower support plates, and wherein a plurality of series of bores are formed in the support plates for the passage of air or other gas for pneumatic operation.

16. A support assembly for selective support of an article from a face thereof, comprising a pneumatic assembly as claimed in any of Claims 7 to 15.

17. A support assembly substantially as hereinbefore described with reference to, and as illustrated by, the accompanying drawings.

18. A pneumatic cylinder substantially as hereinbefore described with reference to, and as illustrated by, any of the accompanying drawings.

19. A pneumatic assembly substantially as hereinbefore described with reference to, and as illustrated by, the accompanying drawings.

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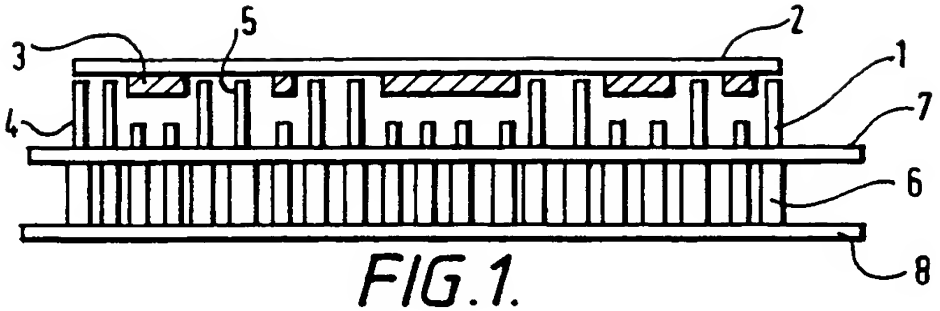

FIG.1.

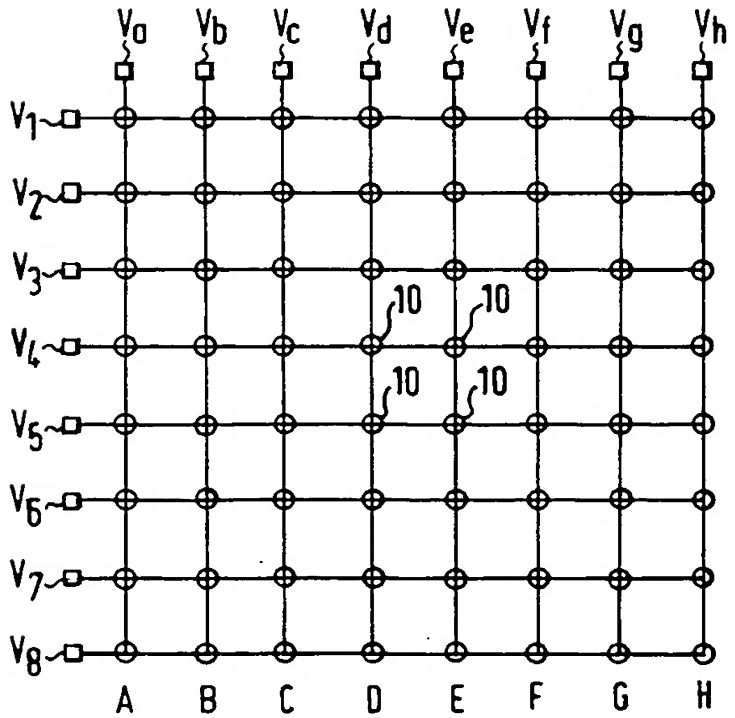

FIG.2.

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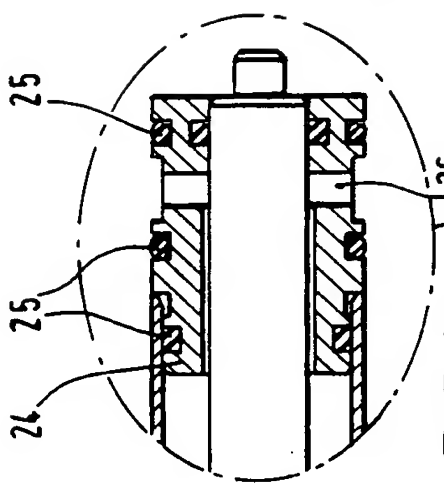

FIG.3c.

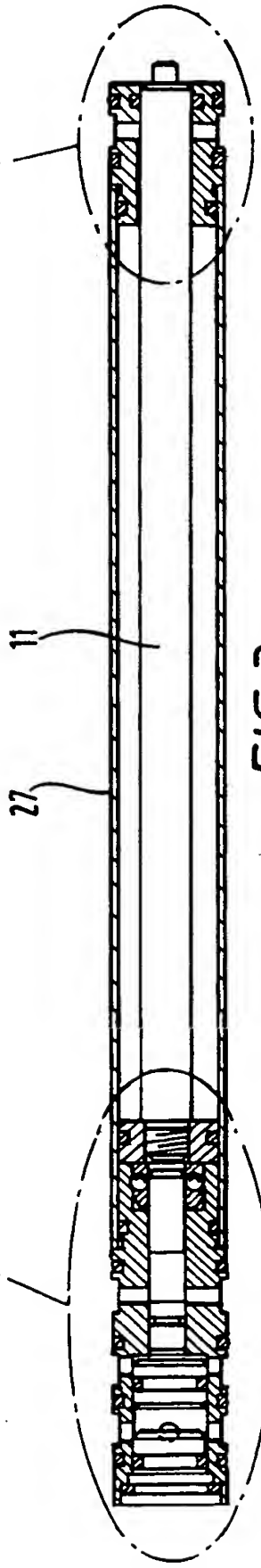

FIG.3a.

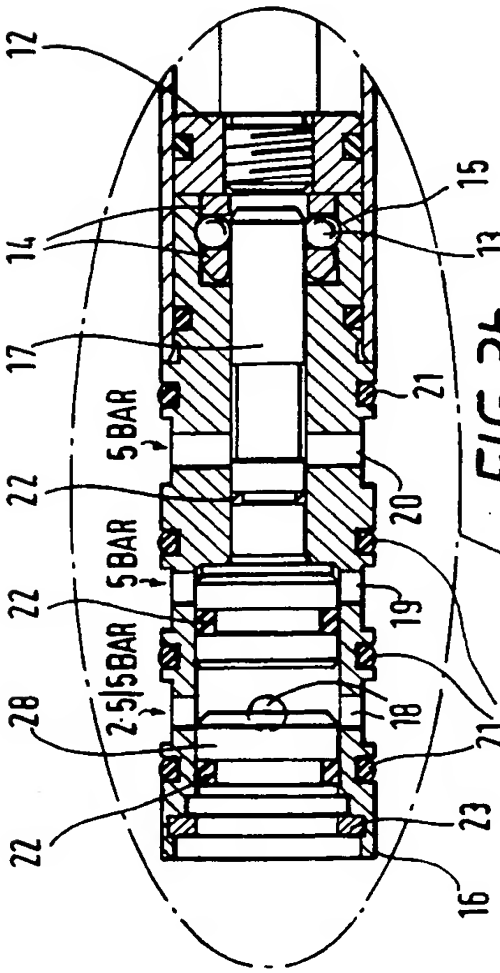

FIG.3b.

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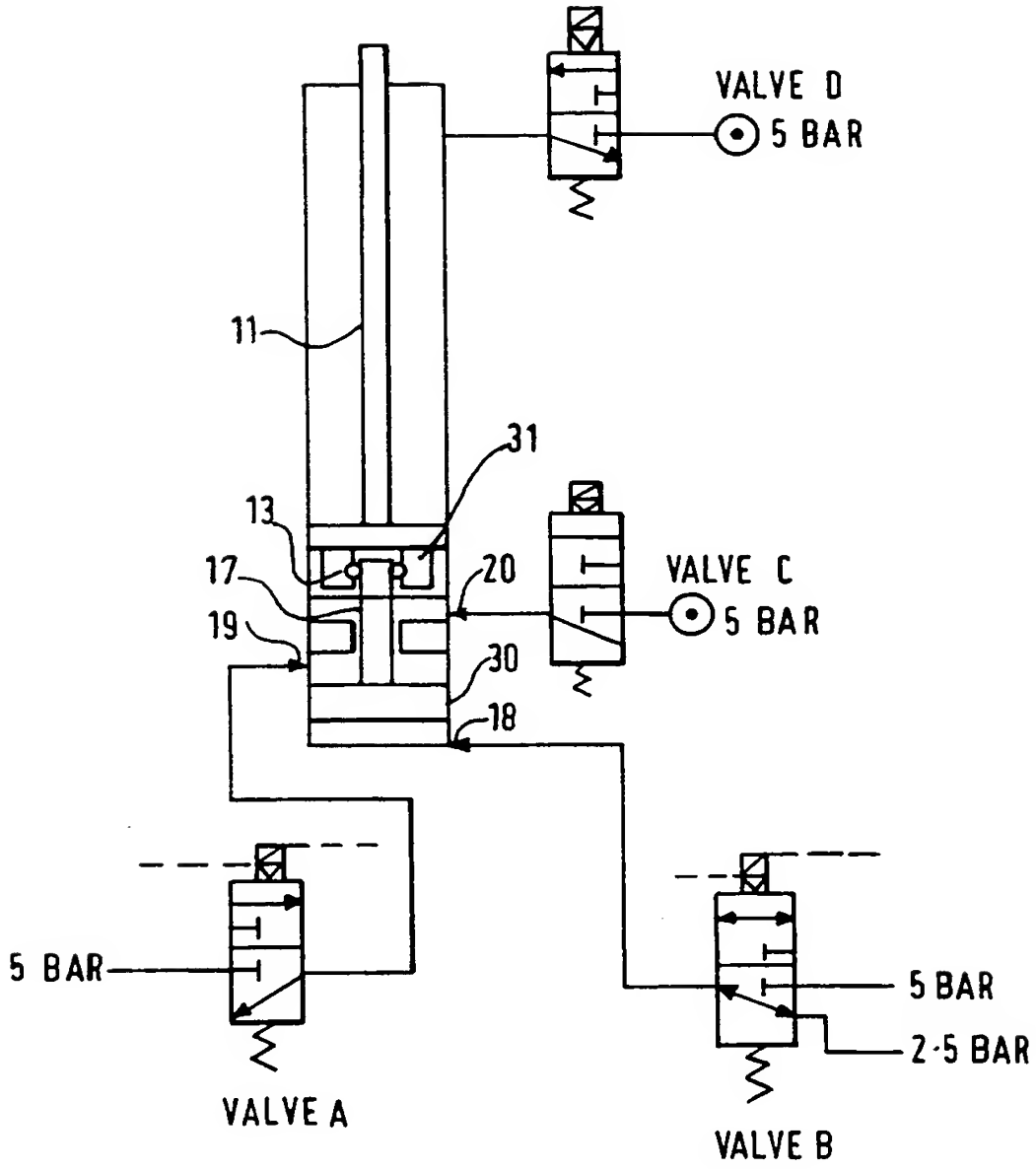

FIG. 4.

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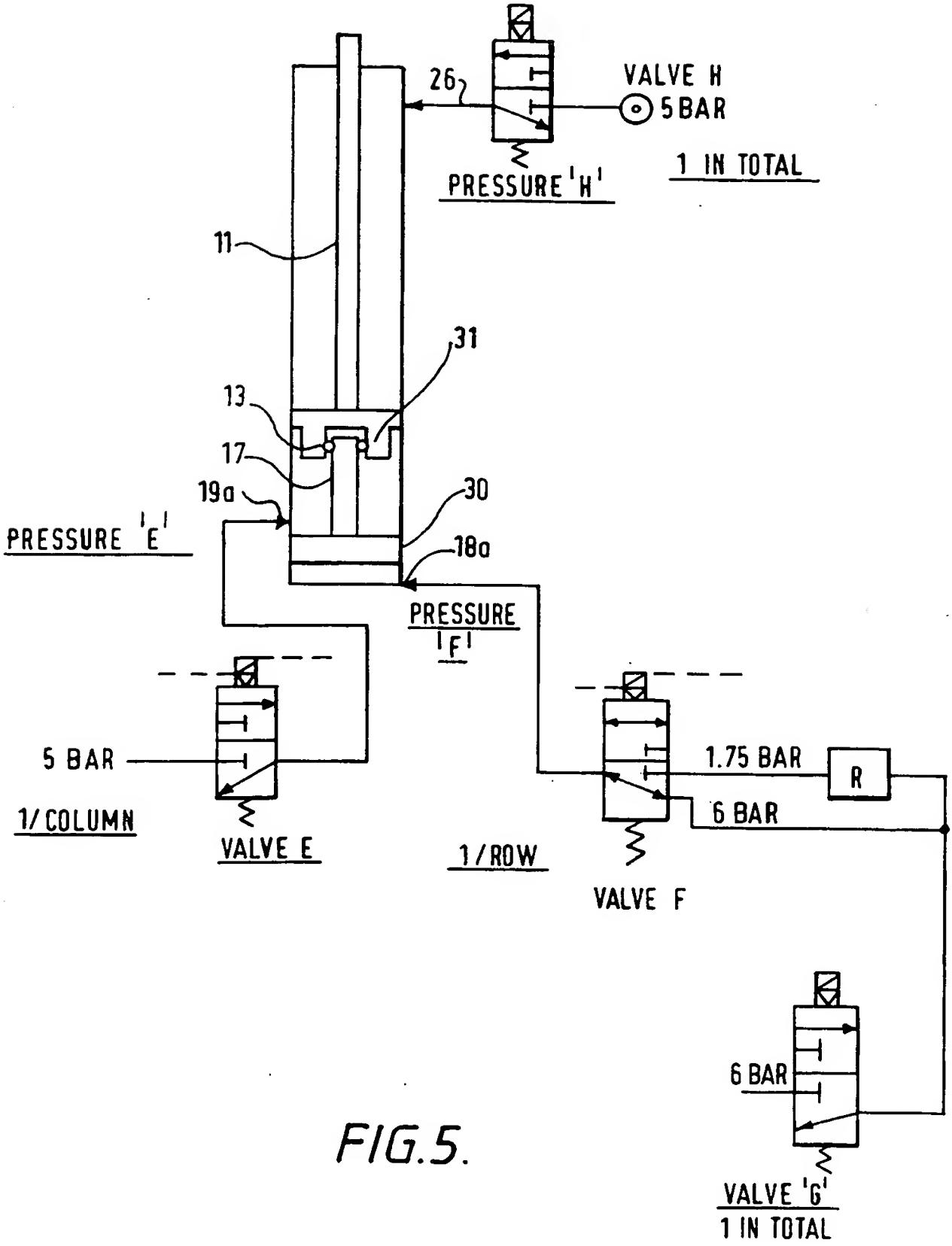

FIG.5.

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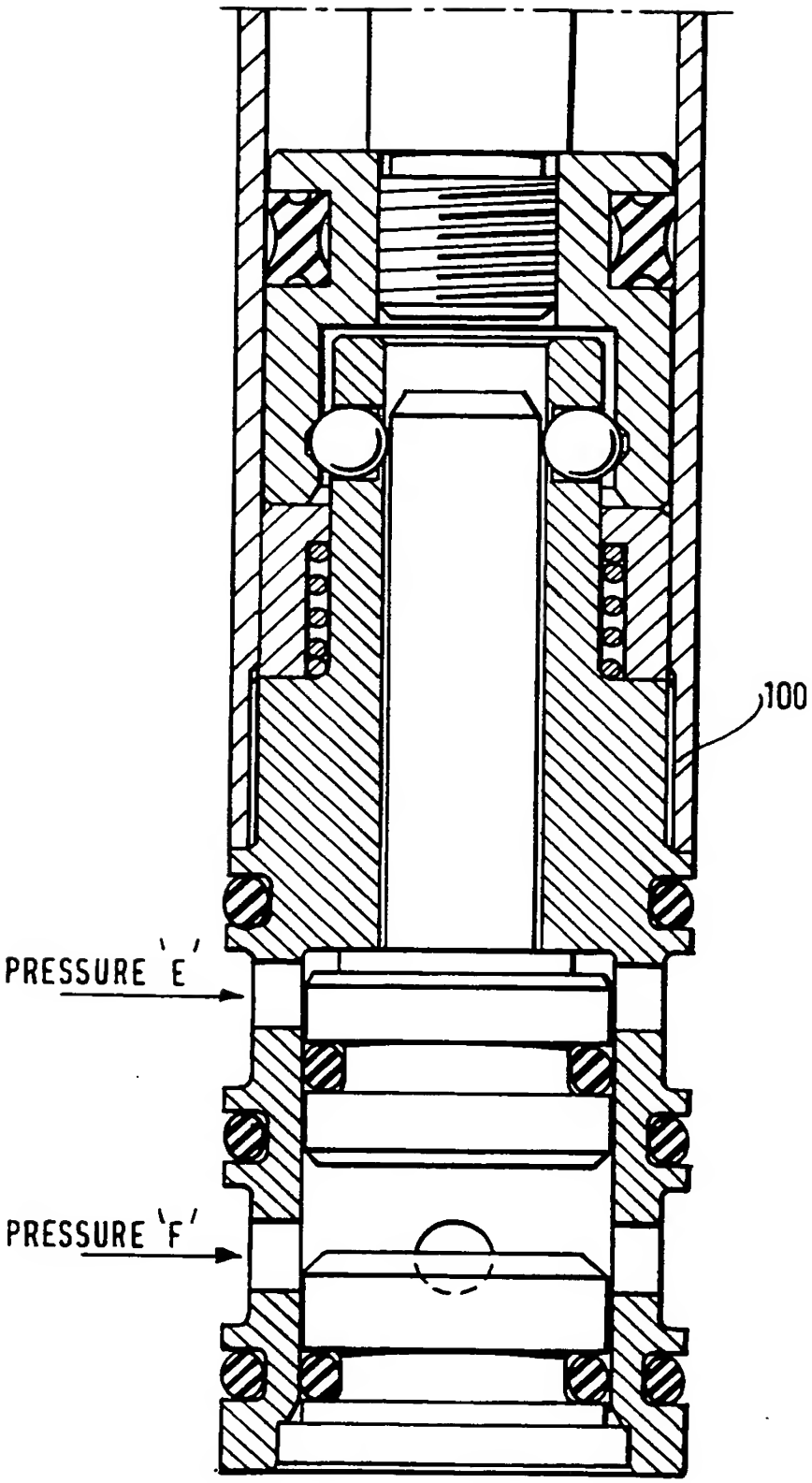

FIG.6.

BNSDOCID: <WO___0008905A2_I_>